Question number	Answer	Marks	Guidance
1 (a)	$n(NaOH) = 0.125 \times 22.40/1000 = 2.80 \times 10^{-3}$ mol	B1	
1 (b)	$n(NaOH) = 0.5 \times 2.80 \times 10^{-3} = 1.40 \times 10^{-3} \text{ mol}$	B1	
1 (c)	$c = 1.40 \times 10^{-3} \times 1000/25.0 = 0.0560 \text{ mol dm}^{-3}$	B1	
2	N in NH ₃ has been oxidised from -3 to 0 in N ₂	B1	
	Cu in CuO has been reduced from +2 to 0 in Cu	B1	
3 (a) (i)	Mg has lost 2 electrons and has been oxidized	B1	
	Fe has lost 3 electrons and has been reduced	B1	
3 (a) (ii)	iron(III) nitrate(V)	B1	
3 (b) (i)	Mn has been reduced from +4 in MnO ₂ to +2 in MnCl ₂	B2	
3 (b) (ii)	In HCl, Cl has oxidation number of –1. Cl has been oxidised from –1 in HCl to 0 in Cl ₂	B1	
	CI in HCI has an oxidation number of –1 which is unchanged in MnCl ₂	B1	
4 (a) (i)	For each equation, 1 mark for balanced equation, 1 mark for state symbols.		
	$CaCO_3(s) + 2HCI(aq) \rightarrow CaCI_2(aq) + CO_2(g) + H_2O(I)$	B1 x 2	
	$CaO(s) + 2HCI(aq) \rightarrow CaCI_2(aq) + H_2O(I)$	B1 x 2	
	$Ca(OH)_2(aq) + 2HCI(aq) \rightarrow CaCI_2(aq) + 2H_2O(I)$	B1 x 2	
4 (a) (ii)	An acid has been neutralised by a base to form water	B1	
4 (a) (iii)	$H^+(aq) + OH^-(aq) \rightarrow H_2O(I)$	B1	
4 (b) (i)	Reduction is increase in oxidation number and gain of electrons	B1	
	Oxidation is decrease in oxidation number and loss of electrons	B1	
4 (b) (ii)	$Ca(s) + 2HCI(aq) \rightarrow CaCI_2(g) + H_2(g)$	B2	
4 (b) (iii)	Ca has been oxidised from 0 to +2	B1	
	H has been reduced from 1+ to 0.	B1	
5 (a)	$WO_3 + 3H_2 \rightarrow W + 3H_2O$	B1	

5 (b)	Question	Answer	Marks	Guidance
H in H₂ has been oxidised from 0 to +1 in H₂O W in WO₃ has been reduced from +6 to 0 in W B1 5 (d) Mass of WO₃ in 100 tonnes of ore = 2 tonnes M(WO₃) = 231.8 g mol⁻¹ R(WO₃) = 2 × 10⁶/231.8 = 8628 mol mass of W = 8628 × 183.8 = 1.59 × 10⁶ g (1.59 tonnes) 6 (a) R(H₂SO₄) = 0.125 × 24.40/1000 = 3.05 × 10⁻ 3 mol 6 (b) R(NH₃) = 2 × 3.05 × 10⁻³ mol = 6.10 × 10⁻³ mol 6 (c) (ii) C = 6.10 × 10⁻³ × 1000/25.0 × 10 (for initial dilution = 2.44 mol dm⁻³ 6 (c) (iii) Q.44 × 17 = 41.46 g dm⁻³ 7 (a) (i) Mg in Mg has been oxidised from 0 to +2 in MgSO₄ H in H₂SO₄ has been reduced from +1 to 0 in H₂ Mg/solid dissolves OR fizzes OR effervesces OR gas produced Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution 7 (b) (i) M(MgSO₄) = 120.4 g mol⁻¹ R(MgSO₄) = 1.51/120.4 = 1.25 × 10⁻² mol B1 ALLOW correct oxidation numbers shown in equation 2nd mark is dependent on identification of Mg IGNORE electrons B1 IGNORE metal reacts IGNORE temperature change IGNORE steam produced DO NOT ALLOW corroot oxidation oxide gas produced DO NOT ALLOW hydrogen produced without gas 7 (b) (i) M(MgSO₄) = 120.4 g mol⁻¹ R(MgSO₄) = 1.51/120.4 = 1.25 × 10⁻² mol B1 ALLOW 0.013 up to calculator value of 0.012 581 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 583 333 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 583 333 correctly			B1	
W in WO₃ has been reduced from +6 to 0 in W B1	5 (c)	H has been oxidised and W has been reduced	B1	
5 (d) Mass of WO₃ in 100 tonnes of ore = 2 tonnes M(WO₃) = 231.8 g moΓ¹ R(WO₃) = 2 × 10⁶/231.8 = 8628 mol mass of W = 8628 × 183.8 = 1.59 × 10⁶ g (1.59 tonnes) 6 (a) R(H₂SO₄) = 0.125 × 24.40/1000 = 3.05 × 10⁻ B1 6 (b) R(NH₃) = 2 × 3.05 × 10⁻³ mol = 6.10 × 10⁻³ mol 6 (c) (i) C = 6.10 × 10⁻³ × 1000/25.0 × 10 (for initial dilution = 2.44 mol dm⁻³ 6 (c) (ii) Z.44 × 17 = 41.46 g dm⁻³ B1 7 (a) (i) Mg in Mg has been reduced from 0 to +2 in MgSO₄ H in H₂SO₄ has been reduced from +1 to 0 in H₂ B1 ALLOW correct oxidation numbers shown in equation 2nd mark is dependent on identification of Mg IGNORE electrons 7 (a) (ii) bubbles OR fizzes OR effervesces OR gas produced Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution 7 (b) (i) M(MgSO₄) = 120.4 g mol⁻¹ R(MgSO₄) = 1.51/120.4 = 1.25 × 10⁻² mol B1 ALLOW correct oxidation numbers shown in equation 2nd mark is dependent on identification of Mg IGNORE temperature change IGNORE steam produced DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW carbon dioxide gas produced without gas ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻¹ ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol⁻² ALLOW 0.013 up to calculator value of 0.012 5415 528 correctly		H in H ₂ has been oxidised from 0 to +1 in H ₂ O	B1	
$M(WO_3) = 231.8 \mathrm{g} \mathrm{mor}^{-1} \qquad \qquad \mathrm{B1}$ $n(WO_3) = 2 \times 10^6 / 231.8 = 8628 \mathrm{mol} \qquad \qquad \mathrm{B1}$ $n(WO_3) = 2 \times 10^6 / 231.8 = 8628 \mathrm{mol} \qquad \qquad \mathrm{B1}$ $mass \mathrm{of} W = 8628 \times 183.8 = 1.59 \times 10^6 \mathrm{g}$ $(1.59 \mathrm{tonnes})$ $6 (a) \qquad n(H_2SO_4) = 0.125 \times 24.40 / 1000 = 3.05 \times 10^{-3} \mathrm{mol}$ $6 (b) \qquad n(\mathrm{NH}_3) = 2 \times 3.05 \times 10^{-3} \mathrm{mol} = 6.10 \times 10^{-3} \mathrm{mol}$ $81 \qquad \qquad \mathrm{B1}$ $6 (c) (i) \qquad c = 6.10 \times 10^{-3} \times 1000 / 25.0 \times 10 (\mathrm{for initial} \mathrm{dilution} = 2.44 \mathrm{mol} \mathrm{dm}^{-3}$ $81 \qquad \qquad \mathrm{B1}$ $7 (a) (i) \qquad Mg \mathrm{in} \mathrm{Mg} \mathrm{has} \mathrm{been oxidised from 0 to +2 \mathrm{in}} \mathrm{numbers shown in equation 2nd mark is \mathrm{dependent on} \mathrm{identification of Mg} \mathrm{IGNORE electrons}$ $7 (a) (ii) \qquad \mathrm{bubbles OR fizzes OR effervesces OR \mathrm{gas} \mathrm{produced} \mathrm{Mg/solid dissolves OR Mg/solid disappears OR} \mathrm{Ng/solid disappears OR} Ng/solid disapp$		W in WO ₃ has been reduced from +6 to 0 in W	B1	
$n(WO_3) = 2 \times 10^6/231.8 = 8628 \text{mol} \\ \text{mass of W} = 8628 \times 183.8 = 1.59 \times 10^6 \text{g} \\ (1.59 \text{tonnes}) \\ \hline \\ 6 (a) \qquad \qquad n(H_2SO_4) = 0.125 \times 24.40/1000 = 3.05 \times 10^{-1} \\ \text{3 mol} \\ \hline \\ 6 (b) \qquad \qquad n(NH_3) = 2 \times 3.05 \times 10^{-3} \text{mol} = 6.10 \times 10^{-3} \text{mol} \\ \hline \\ 6 (c) (i) \qquad \qquad c = 6.10 \times 10^{-3} \times 1000/25.0 \times 10 \text{(for initial} \\ \text{dilution} = 2.44 \text{mol dm}^{-3} \\ \hline \\ 7 (a) (i) \qquad \qquad Mg \text{in Mg has been oxidised from 0 to +2 in} \\ \text{MgSO}_4 \qquad \qquad \qquad \text{Mg in Mg has been reduced from +1 to 0 in H}_2 \\ \hline \\ 7 (a) (ii) \qquad \qquad \text{bubbles OR fizzes OR effervesces OR gas} \\ \text{produced} \qquad \qquad \text{Mg/solid dissolves OR Mg/solid disappears OR} \\ \text{(Mg/solid) forms a solution} \\ \hline \\ 7 (b) (i) \qquad \qquad M(MgSO_4) = 120.4 \text{g mol}^{-1} \\ \text{n(MgSO}_4) = 1.51/120.4 = 1.25 \times 10^{-2} \text{mol} \\ \hline \\ 81 \qquad \qquad \text{ALLOW correct oxidation} \\ \text{noners shown in equation 2nd mark is dependent on identification of Mg} \\ \text{IGNORE temperature change IGNORE steam produced} \\ \text{DO NOT ALLOW hydrogen produced} \\ \text{DO NOT ALLOW hydrogen produced without gas} \\ \text{To unided (from M = 120.4 g mol}^{-1} \\ \text{ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from M = 120.4 g mol}^{-1} \\ \text{ALLOW 0.013 up to calculator value of 0.012 543 333 correctly rounded (from M = 120.4 g mol}^{-1} \\ \text{ALLOW 0.013 up to calculator value of 0.012 543 333 correctly rounded (from M = 120.4 g mol}^{-1} \\ \text{ALLOW 0.013 up to calculator value of 0.012 543 333 correctly} \\ \text{To unique of 0.012 543 333 correctly rounded of 0.012 543 333 correctly} \\ To not make the shade of the shad$	5 (d)	Mass of WO ₃ in 100 tonnes of ore = 2 tonnes	B1	
		$M(WO_3) = 231.8 \text{ g mol}^{-1}$	B1	
(1.59 tonnes) $ (1.59 tonnes) $ $ (2.50 tonnes)$		$n(WO_3) = 2 \times 10^6/231.8 = 8628 \text{mol}$	B1	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		1	B1	
	6 (a)	$n(H_2SO_4) = 0.125 \times 24.40/1000 = 3.05 \times 10^{-3}$ mol	B1	
dilution = 2.44 mol dm ⁻³ 6 (c) (ii) 2.44 × 17 = 41.46 g dm ⁻³ B1 7 (a) (i) Mg in Mg has been oxidised from 0 to +2 in MgSO ₄ H in H ₂ SO ₄ has been reduced from +1 to 0 in H ₂ B1 GNORE electrons 7 (a) (ii) bubbles OR fizzes OR effervesces OR gas produced Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution B1 GNORE metal reacts IGNORE temperature change IGNORE steam produced DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW hydrogen produced without gas 7 (b) (i) M(MgSO ₄) = 120.4 g mol ⁻¹ n(MgSO ₄) = 1.51/120.4 = 1.25 × 10 ⁻² mol B1 ALLOW 0.013 up to calculator value of 0.012 583 333 correctly	6 (b)	$n(NH_3) = 2 \times 3.05 \times 10^{-3} \text{ mol} = 6.10 \times 10^{-3} \text{ mol}$	B1	
7 (a) (i) Mg in Mg has been oxidised from 0 to +2 in MgSO ₄ H in H ₂ SO ₄ has been reduced from +1 to 0 in H ₂ B1 ALLOW correct oxidation numbers shown in equation 2nd mark is dependent on identification of Mg IGNORE electrons 7 (a) (ii) bubbles OR fizzes OR effervesces OR gas produced Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution B1 DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW hydrogen produced without gas 7 (b) (i) $M(MgSO_4) = 120.4 \text{ g mol}^{-1}$ $n(MgSO_4) = 1.51/120.4 = 1.25 \times 10^{-2} \text{ mol}$ B1 ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from $M = 120.4 \text{ g mol}^{-1}$ ALLOW 0.013 up to calculator value of 0.012 583 333 correctly	6 (c) (i)	$c = 6.10 \times 10^{-3} \times 1000/25.0 \times 10$ (for initial dilution = 2.44 mol dm ⁻³	B1	
	6 (c) (ii)	$2.44 \times 17 = 41.46 \mathrm{g}\mathrm{dm}^{-3}$	B1	
H in H_2SO_4 has been reduced from +1 to 0 in H_2 B1 identification of Mg IGNORE electrons 7 (a) (ii) bubbles OR fizzes OR effervesces OR gas produced Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution B1 DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW hydrogen produced without gas 7 (b) (i) $M(MgSO_4) = 120.4 \text{ g mol}^{-1}$ B1 ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from $M = 120.4 \text{ g mol}^{-1}$ ALLOW 0.013 up to calculator value of 0.012 583 333 correctly value of 0.012 583 333 correctly	7 (a) (i)		B1	numbers shown in equation 2nd
7 (a) (ii) bubbles OR fizzes OR effervesces OR gas produced Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution M[MgSO4] = $1.51/120.4 = 1.25 \times 10^{-2}$ mol B1 IGNORE metal reacts IGNORE temperature change IGNORE steam produced DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW hydrogen produced without gas ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from $M = 120.4 \text{g mol}^{-1}$ ALLOW 0.013 up to calculator value of 0.012 583 333 correctly		H in H ₂ SO ₄ has been reduced from +1 to 0 in H ₂	B1	identification of Mg
produced Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution M(MgSO ₄) = $120.4 \mathrm{g}\mathrm{mol}^{-1}$ M(MgSO ₄) = $1.51/120.4 = 1.25 \times 10^{-2}\mathrm{mol}$ B1 IGNORE temperature change IGNORE steam produced DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW hydrogen produced without gas ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from $M = 120.4 \mathrm{g}\mathrm{mol}^{-1}$ ALLOW 0.013 up to calculator value of 0.012 583 333 correctly	- () (!!)			
Mg/solid dissolves OR Mg/solid disappears OR (Mg/solid) forms a solution B1 DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW hydrogen produced without gas 7 (b) (i) $M(MgSO_4) = 120.4 \text{ g mol}^{-1}$ $n(MgSO_4) = 1.51/120.4 = 1.25 \times 10^{-2} \text{ mol}$ B1 ALLOW 0.013 up to calculator value of 0.012 541 528 correctly rounded (from $M = 120.4 \text{ g mol}^{-1}$) ALLOW 0.013 up to calculator value of 0.012 583 333 correctly	/ (a) (II)	1	В1	IGNORE temperature change
$n(\text{MgSO}_4) = 1.51/120.4 = 1.25 \times 10^{-2} \text{mol}$ B1 value of 0.012 541 528 correctly rounded (from $M = 120.4 \text{g mol}^{-1}$) ALLOW 0.013 up to calculator value of 0.012 583 333 correctly			B1	DO NOT ALLOW carbon dioxide gas produced DO NOT ALLOW hydrogen
$n(\text{MgSO}_4) = 1.51/120.4 = 1.25 \times 10^{-2} \text{mol}$ B1 rounded (from $M = 120.4 \text{g mol}^{-1}$) ALLOW 0.013 up to calculator value of 0.012 583 333 correctly	7 (b) (i)	$M(MgSO_4) = 120.4 \text{ g mol}^{-1}$	B1	
		$n(MgSO_4) = 1.51/120.4 = 1.25 \times 10^{-2} \text{ mol}$	B1	rounded (from $M = 120.4 \text{ g mol}^{-1}$) ALLOW 0.013 up to calculator value of 0.012 583 333 correctly rounded (from $M = 120 \text{ g mol}^{-1}$)
ALLOW ecf from incorrect <i>M</i> i.e. 1.51 ÷ <i>M</i>				ALLOW ecf from incorrect M i.e. 1.51 $\div M$
7 (b) (ii) $n(H_2O) = 1.57/18 = 8.72 \times 10^{-2} \text{ mol}$ B1 ALLOW 0.09 up to calculator	7 (b) (ii)	$n(H_2O) = 1.57/18 = 8.72 \times 10^{-2} \text{mol}$	B1	ALLOW 0.09 up to calculator

Question number	Answer	Marks	Guidance
			value of 0.087 222 22
7 (b) (iii)	$x = n(H_2O)/n(MgSO_4) = 7$	B1	ALLOW ecf i.e. answer to (ii) ÷ answer to (i) ALLOW correctly calculated answer from 1 significant figure up to calculator value, ie, x does not have to be a whole number. Likely response = 6.95
8 (a) (i)	The H ⁺ ion in an acid has been replaced by a metal ion/Ca ²⁺	B1	DO NOT ALLOW it has been produced by the reaction of an acid and a base as this is stated in the question.
			IGNORE references to replacement by NH ⁴⁺ ions or positive ions. ALLOW H OR Hydrogen for H ⁺ ; DO NOT ALLOW Hydrogen atoms ALLOW Ca OR Calcium for Ca ²⁺ . DO NOT ALLOW Calcium atoms ALLOW 'metal' for 'metal ion
8 (a) (ii)	$2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(I)$	B1 x 2	ALLOW multiples ALLOW (aq) OR (s) for Ca(OH) ₂
	1 mark for Formulae 1 mark for Balance and state symbols		
8 (a) (iii)	Accepts a proton/H ⁺	B1	ALLOW H ⁺ + OH ⁻ → H2O ALLOW OH ⁻ reacts with H ⁺ OR OH ⁻ takes H ⁺ ALLOW OH ⁻ 'attracts' H ⁺ if 'to form water' is seen DO NOT ALLOW OH ⁻ neutralises H ⁺ ('neutralises' is in the question)
8 (b) (i)	$n(NaOH) = 0.0880 \times 25.0/1000 = 2.20 \times 10^{-3}$ mol	B1	ALLOW 0.0022 OR 2.2 × 10 ⁻³ mol
8 (b) (ii)	$n(H_2SO_4) = 0.5 \times 2.20 \times 10^{-3} = 1.10 \times 10^{-3} \text{ mol}$	B1	ALLOW 0.0011 OR 1.1 × 10 ⁻³ mol
			ALLOW ECF for answer (i)/2 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes
8 (b) (iii)	$c = 0.00110 \times 1000/17.60 = 0.0625 \text{mol dm}^{-3}$	B1	ALLOW 0.063 OR 6.3 x 10 ⁻² mol dm ⁻³ ALLOW ECF for answer (ii) x 1000/17.60

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Question	Answer	Marks	Guidance
number			
			OR ECF from (i) for answer (i)/2 × 1000/17.60 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes
8 (c) (i)	Water of crystallisation	B1	IGNORE hydrated OR hydrous
8 (c) (ii)	$M(Na_2SO_4) = 142.1 \text{ g mol}^{-1}$	B1	ALLOW 142
	x = (322.1 - 142.1)/18.0 = 10	B1	ALLOW M _r expressed as a sum ALLOW ECF from incorrect Mr and x is calculated correctly ALLOW ECF values of x from nearest whole number to calculator value ALLOW 2 marks if final answer is 10 without any working
9 (a)	$n(KOH) = 0.224 \times 25.00/1000 = 5.60 \times 10^{-3} \text{ mol}$	B1	
	$n(\mathbf{A}) = 0.5 \times 5.60 \times 10^{-3} = 2.80 \times 10^{-3} \text{mol}$	B1	
9 (b)	$n(\mathbf{A})$ in 250 cm ³ = 2.80 × 10 ⁻³ × 250/31.25 = 2.24 × 10 ⁻² mol	B1	
	$n = m/M$. :: $M = m/n = 2.6432/2.24 \times 10^{-2}$ = 118 g mol ⁻¹	B1	
9 (c)	H: C: O = 40.68/12.0: 5.08/1.0: 54.24/16.0 = 3.39: 5.08: 3.39	B1	
	Empirical formula = $C_2H_3O_2$	B1	
	Molecular formula = $C_2H_3O_2 \times 118/59$ = $C_2H_3O_2 \times 2 = C_4H_6O_4$	B1	
9 (d)	$\begin{array}{c} C_4H_6O_4(aq) + 2KOH(aq) \rightarrow K_2C_4H_4O_4(aq) + \\ 2H_2O(I) \end{array}$	B1	